U.S. FISH AND WILDLIFE SERVICE
NEW ENGLAND FIELD OFFICE
SPECIAL PROJECT REPORT: FY97-MEFO-1-EC

TOXICITY TESTS
AND
SEDIMENT CHEMISTRY
AT
SITE 9 (NEPTUNE DRIVE DISPOSAL SITE)

U.S NAVAL AIR STATION
BRUNSWICK, MAINE

JANUARY 1997

MISSION

U.S. FISH AND WILDLIFE SERVICE

To conserve, protect, and enhance
the nation's fish and wildlife
and their habitats for the continuing benefit
of the American people

NEW ENGLAND FIELD OFFICE
SPECIAL PROJECT REPORT: FY97-MEFO-1-EC

TOXICITY TESTS
AND
SEDIMENT CHEMISTRY
AT
SITE 9 (NEPTUNE DRIVE DISPOSAL SITE)

U.S. NAVAL AIR STATION
BRUNSWICK, MAINE

Prepared by:

Steven E. Mierzykowski[1], Christopher G. Ingersoll[2],
and Kenneth C. Carr[3]

[1]U.S. Fish and Wildlife Service
Ecological Services
1033 South Main Street
Old Town, Maine 04468

[2]U.S. Geological Survey
Midwest Science Center
4200 New Haven Road, Route 2
Columbia, Missouri 65201

[3]U.S. Fish and Wildlife Service
Ecological Services
22 Bridge Street, Unit #1
Concord, New Hampshire 03301-4986

January 1997

EXECUTIVE SUMMARY

During a remedial investigation of the U.S. Naval Air Station Superfund Site in Brunswick, Maine (NASB), elevated concentrations of total polycyclic aromatic hydrocarbons (max. 383 mg/Kg) were found in the sediments of an unnamed stream that receives stormwater runoff from the Neptune Drive Disposal Site (Site 9), developed areas, and the flightline. To assess the potential risk of these contaminated sediments to aquatic organisms, the U.S. Environmental Protection Agency requested that the U.S. Fish and Wildlife Service conduct a contaminant study in the unnamed stream. The purposes of the study were:

1) to determine the concentrations of polycyclic aromatic hydrocarbons (PAHs) and other environmental contaminants in sediments of an unnamed stream near Site 9, and

2) to determine if the chemical constituents within the sediments were toxic to two test organisms, *Hyalella azteca* and *Chironomus tentans*.

Twelve sediments samples were collected with an Ekman dredge or stainless-steel spoon from four locations on August 9, 1995. Three samples were collected from one location in Mere Brook, a reference area northwest of the NASB runway, and nine samples were collected from three locations in the unnamed stream associated with Site 9. The three locations in the Site 9 stream were in the vicinity of locations sampled for the NASB remedial investigation.

Toxicity tests were conducted with *Hyalella azteca*, an amphipod, for 42 days and with *Chironomus tentans*, a midge, for 10 days. Endpoints measured in the amphipod test were survival, growth (length, weight), and reproduction (number of young/female). Endpoints measured in the midge test were survival and growth (head capsule width, weight). Chemical analyses of NASB sediments included: polycyclic aromatic hydrocarbons (PAHs); organochlorines, including total polychlorinated biphenyls (PCBs); trace elements; acid volatile sulfide (AVS) and simultaneously extracted metals (SEM). Physical characterizations of NASB sediments included loss on ignition (organic content), percent moisture, and particle size.

Results from this study indicate that NASB sediments from an unnamed stream associated with Site 9 and the flightline drainage were not toxic to *Hyalella azteca* or *Chironomus tentans*. In the test with *Hyalella azteca*, survival, weight, and reproduction were not significantly reduced in the test sediments relative to the control sediment. In the test with *Chironomus tentans*, neither survival nor weight were significantly reduced in the test sediments relative to the control sediment. Compared to the remedial investigation results, highly elevated 3PAH sediment concentrations were not detected during this study. Sediment analyses also did not indicate highly elevated concentrations of trace elements or organochlorines. Relationships between SEM and AVS indicate a low likelihood for toxicity and bioavailability from exposure to contaminants in the unnamed stream associated with Site 9.

PREFACE

This report describes the results of a study to measure toxicity and sediment chemistry at Site 9 (Neptune Drive Disposal Site), U.S. Naval Air Station, Brunswick, Maine. Funding for this study was provided by Region 1 of the U.S. Environmental Protection Agency (EPA) under an interagency agreement between the U.S. Fish and Wildlife Service and EPA for technical assistance in the Superfund Program (EPA/IAG #DW14934248-01-F).

Questions and comments to this report are encouraged. Written inquiries should be sent to:

Steve Mierzykowski
U.S. Fish and Wildlife Service
Ecological Services
1033 South Main Street
Old Town, Maine 04468

ACKNOWLEDGEMENTS

Access to Site 9 and Mere Brook was facilitated by Jim Caruthers, the U.S. Naval Air Station's Environmental Engineer. Field support was provided by Tim Prior and Ken Munney (USFWS/New England Field Office), and Dave McDonald (Lockheed/Environmental Services Assistance Team). Sample processing and analytical support was provided by Jesse Arms and Tom May of the U.S. Geological Survey's Midwest Science Center. Bob Lim and Susan Svirsky (EPA/Region 1) provided administrative assistance and arranged funding.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A.

Final Laboratory Report FY96-32-07, Determination of acid volatile sulfide and simultaneously extractable cadmium, copper, mercury, lead, nickel, and zinc from sediments collected from Brunswick, Rio Grande, Barton Springs, and West Bearskin. National Biological Service*. Midwest Science Center. Columbia, MO.

Appendix B.

Final Laboratory Report FY96-32-09 (Revised 1/24/97), Determination of PCBs, organochlorines, PAHs, and total recoverable metals in sediments from the Brunswick Naval Air Station. National Biological Service. Midwest Science Center. Columbia, MO.

*The National Biological Service became the Biological Resources Division of the U.S. Geological Survey in October 1996.

INTRODUCTION

During a remedial investigation of the U.S. Naval Air Station Superfund Site in Brunswick, Maine, elevated concentrations of total polycyclic aromatic hydrocarbons (max. 383 mg/Kg) were found in the sediments of an unnamed stream that receives stormwater runoff from the Neptune Drive Disposal Site (hereafter referred to as Site 9), developed areas, and the flightline. To assess the potential risk of these contaminated sediments to aquatic organisms, the U.S. Environmental Protection Agency (EPA) requested that the U.S. Fish and Wildlife Service (USFWS) conduct a contaminant study in the unnamed stream. The USFWS and the U.S. Geological Survey's Midwest Science Center (MSC), through an existing interagency agreement (#14-48-0005-94-9050), collaborated in the study described below.

STUDY PURPOSE

The purpose of the study was to determine the concentrations of polycyclic aromatic hydrocarbons (PAHs) and other environmental contaminants in sediments of an unnamed stream near Site 9, and to determine if the chemical constituents within the sediments were toxic to two test organisms, *Hyalella azteca* and *Chironomus tentans*.

STUDY AREA

The study was conducted at the U.S. Naval Air Station in Brunswick (NASB), Cumberland County, Maine. NASB is in the village of Brunswick approximately 2 miles east of the Town of Brunswick. Brunswick is located in southern Maine, 26 miles northeast of Portland, Maine's largest city (Figure 1). NASB is an active U.S. Navy installation supporting antisubmarine warfare operations.

Site 9 and the unnamed stream are located on the east-central portion of NASB. The stream receives drainage from outfalls associated with the flightline, Neptune Drive, and parking lots. The wetland habitats associated with the stream are classified as palustrine forested and palustrine emergent in the National Wetland Inventory System (Cowardin et al 1979). The banks of the unnamed stream are steep; the bank sides are approximately two to three feet above the stream surface. The dominant canopy cover is comprised of white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*), red maple (*Acer rubrum*), and bigtooth aspen (*Populus grandidentata*). The stream banks support skunk cabbage (*Symplocarpus foetidus*), moss (*Sphagnum* spp.), grasses (*Gramineae*), sedges (*Carex* spp.), goldenrod (*Solidago* spp.), and nightshade (*Solanum dulcamara*). Hummocks within the stream channel support broad-leaved cattail (*Typha latifolia*), wool grass (*Scirpus cyperinus*), nightshade, and dense stands of jewelweed (*Impatiens capensis*). The stream substrate is primarily coarse sand. A reference location was chosen at Mere Brook on the northwest portion of the installation (Figure 2). The riparian vegetation was similar to the Site 9 stream, but the stream substrate was slightly more organic.

Initially, samples were scheduled for collection on July 24, 1995. However, a spill on the flightline released fuel into the Site 9 stream the previous day and sample collection was delayed until August.

METHODS

Sample collection:

Twelve sediments samples were collected with an Ekman dredge or stainless-steel spoon from four NASB locations on August 9, 1995. The top 5 cm of sediment were collected from each location and placed in precleaned jars or polyethylene containers. Three samples were collected from one location in Mere Brook, a reference area northwest of the NASB runway (Figure 2), and nine samples were collected from three locations in the unnamed stream associated with Site 9. The three locations in the Site 9 stream were in the vicinity of locations sampled for the NASB remedial investigation (Figure 3). During the remedial investigation (ABB 1994), three locations within the Site 9 stream were found to contain highly elevated levels of 3PAHs. 3PAH concentrations at SW/SD 011, SW/SD-921, and SW/SD-916 were 383.1 mg/Kg, 149.0 mg/Kg, and 12.9 mg/Kg, respectively. We relocated the remedial investigation sampling stakes for these locations and collected new samples for this study.

At each location, three sediment samples were collected: a 10 L sample for whole-sediment *Hyalella azteca* and *Chironomus tentans* toxicity tests, a 125 ml sample for acid volatile sulfide and simultaneously extracted metals (AVS/SEM), and a 500 ml sample for sediment chemistry. Samples were stored in coolers filled with wet ice during transport to the USFWS office in Old Town, Maine, and stored overnight in a refrigerator (AVS/SEM, whole-sediment toxicity test) or freezer (sediment chemistry). Samples were shipped via overnight express on August 10, 1996 in ice-filled coolers to the USGS's Midwest Science Center.

Culture of test organisms:

Tomasovic et al. (1995) described the procedure used to obtain 7-d old *Hyalella azteca* to start the toxicity test. Mixed-age amphipods were cultured at 23ºC at a luminance of about 500 lux in 80-L glass aquaria containing 50 L of water and receiving about 6 volume additions/d of well water (hardness 283 mg/L as $CaCO_3$). Amphipods in the mixed-age cultures were fed Tetramin fish food (Ram Fab Aquarium Products, Oak Ridge, TN) and pre-soaked maple leaves *ad libitum*. Each aquarium contained six artificial substrates (20-cm-diameter sections of "Coiled-web material"; 3-M, St. Paul, MN). Known-age amphipods were obtained by sieving organisms from the mixed-aged culture through a #25 (710-:m mesh) U.S. standard size sieve placed under water. Mature amphipods remaining in the #25 sieve were then pipeted into a #40 (425-:m) mesh sieve placed in a shallow glass pan containing water. The mature amphipods were left in the pan overnight to release new-born amphipods. After 24 h, the sieve was shaken while water was poured through the sieve to rinse <24-h-old amphipods through the #40 sieve into the surrounding water. The <24-h-old amphipods were held for 7 d before the start of the test in a 2-

L beaker. The <24-h amphipods were fed 10 ml of YCT and 5 ml of *Selenastrum capricornutum* (about 300 x 10^6 cells/L) on the first day of isolation and 5 ml of both YCT and *S. capricornutum* on the 3rd and 5th day after isolation.

ASTM (1995) described the procedure used to obtain known-age *Chironomus tentans* to start the toxicity test (see Section 12.4.5 of ASTM 1995 for additional detail). Midges were cultured at 23°C at a luminance of about 500 lux in 5.7-L polyethylene cylindrical containers. Each 5.7-L culture chamber contains about 3 L of well water and about 25 ml of fine sand. Culture water was aerated and about 90% of the water was replaced weekly. New chambers are started with 3 to 5 egg cases. Eight to ten chambers are used to maintain the culture. Midges in each chamber were fed 2 ml of a 100 g/L suspension of Tetrafin suspension five times/week. A 2-ml chlorella suspension of deactivated *Chlorella* suspension is added to each chamber two time/week. The chlorella suspension is prepared by adding 5 g of dry chlorella powder/L of water. Egg cases are removed from the culture chambers and placed in 200 ml of well water in a 250-ml beaker. The larvae begin hatching in about 2 to 3 days. Larvae are then transferred into a culture chamber for 10 days and are fed Tetrafin as described above.

Toxicity tests:

Toxicity tests were conducted with *H. azteca* for 42 d and with *C. tentans* for 10 d following procedures outlined in Ingersoll and Nelson (1990), USEPA (1994), and ASTM (1995; Table 2). Endpoints measured in the amphipod test were survival, growth (length, weight), and reproduction (number of young/female). Endpoints measured in the midge test were survival and growth (head capsule width, weight).

Tests were started with 7-d old amphipods or 3rd instar midges. At the start of a test, twenty amphipods or midges were archived in sugar formalin for later measurement of amphipod length or midge head capsule width (Ingersoll and Nelson 1990). Ten amphipods or midges were exposed in 100 ml of sediment with 175 ml of overlying water in 300-ml beakers. Exposures were conducted at 23°C on a 16L:8D photoperiod at a light intensity of about 500 to 1000 foot candles. Eight replicate beakers/sediment were tested in the amphipod test and 4 replicate beakers/sediment were tested in the midge test. The day before start of the sediment test (Day -1) each sediment sample was thoroughly mixed, visually inspected to judge homogeneity, and was then added to the test beakers. The control sediment was a fine sediment obtained from West Bearskin Lake in Minnesota (Ankley et al. 1994). Well water was the source of overlying water and was added on Day -1 in a manner that minimized suspension of sediment. Overlying water was renewed twice daily using an automated system (Zumwalt et al. 1994). Amphipods were fed a 1.5 ml mixture of yeast-cerophyll-trout chow (YCT; 1800 mg/L stock solution) three/week (ASTM 1995; note: subsequent studies have modified this feeding rate to 1.0 ml of YCT daily). Midges were fed 1.5 ml suspension of Tetrafin (4 g/L) daily (ASTM 1995).

On Day 10 of the midge test, sediment in each of the 4 replicate beakers/treatment was sieved through a #25 mesh sieve. Surviving midges were counted and preserved in a sugar formalin solution for later head capsule width and weight measurements (USEPA 1994, ASTM 1995). On Day 28 of the amphipod test, 4 of the replicate beakers/sediment were sieved through a #25 mesh sieve and surviving amphipods were preserved in sugar formalin for later length and weight measurements (Kemble et al. 1997). The remaining 4 replicate beakers/sediment containing amphipods were also sieved on Day 28. The surviving amphipods isolated from each of these sediment beaker were place in 300-ml water-only beakers containing 275 ml of overlying water and a 5 cm x 5 cm piece of Nitex screen (Nylon bolting cloth; 44% open area and 280-:m aperture, Wildlife Supply Company, Saginaw, MI). Each water-only beaker received two volume additions of overlying water daily and 1.5 ml of the YCT stock solution three times/week. Reproduction of amphipods was then measured on Day 35 and Day 42 in these water-only beakers. Adult amphipods surviving on Day 42 were preserved in sugar formalin. The number of adult males and females in each beaker was determined from this archived Day 42 sample (mature male amphipods will have an enlarged second gnathopod). This information was used to calculate the number of young produced/female/beaker from Day 28 to Day 42.

The following characteristics of the overlying water were measured on Day -1 (the day before organisms were placed into beakers) and at the end of each toxicity test: dissolved oxygen, temperature, conductivity, pH, alkalinity, total hardness, and total ammonia (Table 3). Dissolved oxygen was also measured weekly in the amphipod exposure. Overlying water quality characteristics were similar among all treatments and the in flowing test water. Dissolved oxygen measurements were at or above acceptable levels in all treatments throughout the study (>40% saturation; ASTM 1995).

About 170 ml of pore water was isolated from each sample by centrifugation at 4^{o}C for 15 min at 5200 rpm (7000 x G) before the start of the toxicity tests. Subsamples of pore water were analyzed for total sulfide and ammonia, alkalinity, pH, hardness, conductivity, and dissolved oxygen using methods described in Kemble et al. (1997). Characteristics of pore water were similar among the treatments and the control. Exceptions were lower hardness and alkalinity in pore water sampled from NASB-07 and NASB-10 (Table 4).

Statistical analyses:

Statistical analyses were conducted using one-way analysis of variance (ANOVA) at alpha = 0.05 for all endpoints except length of amphipods and midge head capsule width. Amphipod length and midge head capsule width were analyzed using one-way nested ANOVA at alpha = 0.05. Percent survival data were arcsin transformed before analysis. Mean separation was performed by Fisher s protected least-significant difference test at alpha = 0.05. All statistical analyses were performed with Statistical Analyses Systems programs (SAS 1994).

Chemical and physical characterization of sediment samples:

Chemical analyses of NASB sediments included: polycyclic aromatic hydrocarbons (PAHs); organochlorines, including total polychlorinated biphenyls (PCBs); trace elements (aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel vanadium, zinc, strontium, selenium, and mercury; acid volatile sulfide (AVS) and simultaneously extracted metals (SEM). Physical characterizations of NASB sediments included loss on ignition (organic content), percent moisture, and particle size (USEPA 1996; Table 5).

The laboratory report detailing the determination of acid volatile sulfide and simultaneously extractable cadmium, copper, mercury, lead, nickel, and zinc from NASB sediments are presented in Appendix A.

The laboratory report containing the concentrations of PCBs, organochlorines, PAHs, and total recoverable metals in sediment samples are presented in detail in Appendix B. The results are summarized below and in Tables 8 and 9.

Polycyclic aromatic hydrocarbons (PAHs) - All samples contained detectable concentrations of several PAHs (Table 8 lists the PAH compounds included in the analyses). 3PAH concentrations for the four NASB sediment samples ranged from 1.5 to 9.0 mg/Kg (ppm).

Organochlorines - Except for DDT metabolites in three samples, organochlorines and PCBs were not detectable in NASB sediment samples. In NASB-04, o,p'-DDD was detected at 3.60 :g/Kg and 4,4'-DDD was found at 11.10 :g/Kg (ppb). In NASB-01 and NASB-07, 4,4'-DDT was detected at 3.80 and 6.10 :g/Kg, respectively.

Metals - Arsenic, boron, mercury, selenium, and strontium were not detected in any sample. Concentrations of biologically significant metals found in each sampling location are listed in Table 9. Detectable metal ranges were as follows, in mg/Kg (ppm) dry weight,: aluminum 715 to 1,880; barium 5.59 to 22.0; beryllium <0.1 to 0.3, cadmium <0.25 to 0.25; chromium 1.94 to 12.8; copper 3.81 to 5.05; iron 897 to 3,290; lead 6.01 to 34.8; magnesium 118 to 416; manganese 64.3 to 283; molybdenum <0.025 to 0.238; nickel 1.06 to 3.74; vanadium 2.17 to 5.22; and zinc 13.3 to 33.9.

AVS/SEM - Acid volatile sulfide and simultaneously extracted metals were measured in two samples from each location - in a dedicated AVS/SEM sediment sample and in the bulk toxicity test sediment sample (Table 10). AVS values, as :Mol/g dry weight, at the Mere Brook reference location were 3.37 (NASB-02) and 2.16 (NASB-01). AVS in six samples from the three Site 9 stream locations ranged from 0.002 to 0.023. SEM (summed molar concentrations of cadmium, copper, nickel, lead, and zinc) values at Mere Brook were 0.674 :Mol/g (NASB-02)and 0.077 :Mol/g (NASB-01). In the Site 9 stream samples, SEM values ranged from 0.582 to 0.411 :Mol/g.

Organic content - Organic content, expressed as Loss on Ignition (LOI), was measured in two samples from each sampling location. The Mere Brook reference location contained organic matter of 5.0% (NASB-02) and 4.9% (NASB-01). LOI in six samples from the three Site 9 stream locations ranged from 0.3% to 0.5%.

Quality control procedures included recoveries of surrogate compounds, spike blanks, duplicate analyses of unspiked and spiked samples, and method blanks (Appendices A and B). Quality control results were considered within the acceptable limits established by the Midwest Science Center.

RESULTS AND DISCUSSION

Toxicity tests:

In the 42-d test with *Hyalella azteca*, survival, weight, and reproduction were not significantly reduced in the test sediments (NASB-01, NASB-04, NASB-07, and NASB-10) relative to the control sediment (Table 6). Amphipod length was significantly greater in sediment from station NASB-10 relative to the other sediment treatments. In the 10-d test with *Chironomus tentans*, neither survival nor weight were significantly reduced in the test sediments relative to the control sediment (Table 7). Head capsule width of midges was significantly greater with exposure to test sediment from station NASB-10. While there was a significant reduction in head capsule width with exposure to NASB-04 sediments relative to the control, midge in all of the treatments including NASB-04 were at the 4th instar of development by the end of the test (USEPA 1994). Hence, the reduction in head capsule width with exposure to NASB-04 was probably not of ecological importance.

Chemical and physical characterization of sediment:

PAHs - PAHs were detected at all NASB sampling locations. 3PAH sediment concentrations (max. 9.0 mg/Kg at NASB-07) found in this study did not approach the levels detected during the remedial investigation (max. 383 mg/Kg). Of the 22 PAH compounds included in the chemical analyses, fluoranthrene, phenanthrene, and pyrene were above 1 mg/Kg and were highest at NASB-07. 3PAH concentrations in excess of 2 - 4 mg/Kg are considered elevated and potentially harmful to biota (Long and Morgan 1991, Ingersoll et al 1996). Two locations in the Site 9 stream contained 3PAHs above 2 mg/Kg. However, bioassays did not indicate toxicity. Sediment binding factors in the stream (see AVS/SEM section) may also be limiting toxicity and bioavailability.

Organochlorines - The only two organochlorines detected (2 DDT metabolites) were not elevated and are not considered a potential risk to ecological receptors.

Metals - Similarly, metal concentrations were low or not detected. Arsenic, boron, mercury, selenium, and strontium were not detected in NASB sediments. Aluminum, beryllium, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, vanadium, and zinc were detected. Cadmium and molybdenum were not detected in sediments from the reference area. Aluminum, beryllium, iron, magnesium, manganese, nickel, vanadium, and zinc were detected at the reference area in higher concentrations than at the Site 9 stream. Metal concentrations in Mere Brook and the Site 9 stream were compared to freshwater biological effect levels (Ingersoll et al 1996). The concentrations of metals found in NASB sediments were less than effect levels and not expected to be toxic to test organisms (Table 9).

<u>AVS/SEM</u> - Acid volatile sulfides and simultaneously extracted metal ratios can be used to predict toxicity or degree of bioavailability for certain inorganic contaminants (Ankley et al 1994) under certain conditions. A SEM:AVS ratio <1 often indicates that metals are not toxic or bioavailable. However, a SEM:AVS ratio >1 does not always indicate toxicity or increased bioavailability. At the Mere Brook reference location, the ratio of SEM/AVS was 0.2 and 0.36 indicating that the potential for toxicity from cadmium, copper, nickel, lead, and zinc would be low. AVS concentrations at the Site 9 stream locations, however, were very low, < 0.05 :Mol/g, and the SEM/AVS ratio was considerably higher than one. When bioassays are negative for toxicity and the SEM/AVS is greater than one, other binding phases are likely controlling bioavailability (Hansen et al 1996). Hansen et al (1996) suggested that SEM minus AVS may provide a more reasonable measure of sediment binding capacity. SEM minus AVS values were <1 in the 6 samples from the unnamed stream associated with Site 9.

<u>Physical Characteristics</u> - Organic content, expressed as % Loss on Ignition (Table 5), was 4.9% in the Mere Brook reference area. Organic content in the Site 9 stream was less than 0.5%. Grain size analyses of samples from stations NASB-04, NASB-07, and NASB-10 in the Site 9 stream indicate a sand sediment (particle size >90% sand, Table 5). The laboratory control sediment and the sediment from NASB-01, the Mere Brook reference location, were less sandy than Site 9 sediments with a slightly higher percentage of silt and clay (Table 5). Field surveys within the Site 9 stream indicate that sand predominates, and sediment samples were representative of the stream substrate. Coarse sand with small stones was found at depths over 36 cm in the Site 9 stream channel.

Comparisons of sediment chemistry to Effect Range Medians (ERMs):

Results of sediment toxicity tests were evaluated by comparing sediment chemistry to ERMs reported in Ingersoll et al. (1996) for 28-d toxicity tests with *Hyalella azteca*. These ERMs were calculated for individual chemicals as the median concentration for toxic sediment samples in the database. Toxicity endpoints measured in these 28-d tests included effects of sediments on survival, growth, or sexual maturation of amphipods. Ingersoll et al. (1996) reported ERMs primarily for metals and polycyclic aromatic hydrocarbons. Use of ERMs to classify samples as toxic or not toxic minimized Type I (false positive) and Type II (false negative) errors relative to other sediment effect concentrations reported in Ingersoll et al. (1996).

Figure 4 illustrates the relationship between the proportion of ERMs exceeded and the mean ERM quotient for each sediment sample reported in Ingersoll et al. (1996), Kemble et al. (1997), and in the present study. The proportion of ERMs exceeded was calculated for each sample by dividing the number of ERMs exceeded by the total number of ERMs evaluated. An ERM quotient was calculated for each sample by summing the concentration of each chemical divided by the ERM for that chemical. The mean ERM quotient was calculated by dividing the ERM quotient by the total number of ERMs evaluated.

In sediment toxicity tests conducted by Ingersoll et al. (1996) and Kemble et al. (1997), the frequency of samples classified as toxic was highest when a proportion of ERMs exceeded >0.4 or at a mean ERM quotient of >2. In the present study, the proportion of ERMs exceeded was <0.2 and the mean ERM quotient was <2 (Figure 4 and Table 5). Hence, samples in the present study would not be predicted to be toxic which is consistent with the lack of toxicity observed in these samples.

CONCLUSIONS

Toxicity Tests - NASB sediments from an unnamed stream associated with Site 9 and the flightline drainage were not toxic to the amphipod *Hyalella azteca* or the midge *Chironomus tentans*. In the test with *Hyalella azteca*, survival, weight, and reproduction were not significantly reduced in the test sediments relative to the control sediment. In the test with *Chironomus tentans*, neither survival nor weight were significantly reduced in the test sediments relative to the control sediment.

Sediment Chemistry - Compared to the remedial investigation results, highly elevated 3PAH sediment concentrations were not detected during this study. Sediment analyses also did not indicate highly elevated concentrations of trace elements or organochlorines.

AVS/SEM - The ratio of SEM/AVS was less than one in the Mere Brook reference samples indicating a low likelihood of toxicity and bioavailability. Very low AVS was found in Site 9 stream sediments, and SEM minus AVS also suggested a low potential for toxicity or bioavailability.

LITERATURE CITED

ABB Environmental Services, Inc. 1994. Draft final technical memorandum - Site 9 Neptune Drive disposal site. Naval Air Station, Brunswick, ME. Project No. 7127-09. Portland, ME.

American Society for Testing and Materials. 1995. Standard test methods for measuring the toxicity of sediment-associated contaminants with freshwater invertebrates. E1706-95b. In Annual Book of Standards, Vol. 11.05, Philadelphia, PA, pp. 1204-1285.

Ankley, G.T., D.A. Benoit, J.C. Balogh, T.B. Reynoldson, K.E. Day, and R.A. Hoke. 1994. Evaluation of potential confounding factors in sediment toxicity tests with three freshwater benthic invertebrates. Environ. Toxicol. Chem. 13:621-626.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetland and deepwater habitats of the United States. U.S. Dept. Interior. FWS/OBS-79/31. Washington, D.C. 131 pp.

Hanson, D.J., W.J. Berry, J.D. Mahony, W.S. Boothman, D.M. DiToro, D.L. Robson, G.T. Ankley, D. Ma, Q. Yan, and C.E. Pesch. 1996. Predicting the toxicity of metal-contaminated field sediments using interstitial concentrations of metals and acid-volatile sulfide normalizations. Environ. Toxicol. Chem. 15(12):2080-2094.

Ingersoll, C.G., and M.K. Nelson. 1990. Testing sediment toxicity with *Hyalella azteca* (Amphipoda) and *Chironomus riparius* (Diptera). In Aquatic Toxicology and Risk Assessment: 13th Volume, ASTM STP 1096, W.G. Landis and W.H. van der Schalie (eds.). American Society for Testing and Materials, Philadelphia, pp. 93-109.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. J. Great Lakes Res. (22):602-623.

Kemble, N.E., E.L. Brunson, T.J. Canfield, F.J. Dwyer, and C.G. Ingersoll. 1997. Assessment of toxicity in sediment samples collected from the upper Mississippi River. Manuscript in review.

Long, E.R. and L.G. Morgan. 1991. The potential for biological effects of sediment-sorbed contaminants tested in the national status and trends program. NOAA Tech Mem NOS OMA 52. Seattle, WA.

SAS Institute. 1994. SAS User s Guide: Statistics, Version 6.10 Edition, Cary, SC.

Tomasovic, M.J., F.J. Dwyer, I.E. Greer, and C.G. Ingersoll. 1995. Recovery of known-age *Hyalella azteca* (Amphipoda) from sediment toxicity tests. Environ. Toxicol. Chem. 14:1177-

1180.

U.S. Environmental Protection Agency. 1994. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. EPA 600/R-94/024, Duluth, MN.

U.S. Environmental Protection Agency 1996. Calculation and evaluation of sediment effect concentrations. National Biological Service final report for the USEPA GLNPO assessment and remediation of contaminated sediments project. EPA 905-R96-008, Chicago, IL.

Zumwalt, D.C., F.J. Dwyer, I.E. Greer, and C.G. Ingersoll. 1994. A water-renewal system that accurately delivers small volumes of water to exposure chambers. Environ. Toxicol. Chem. 13:1311-1314.

FIGURES

Figure 1. Location Map

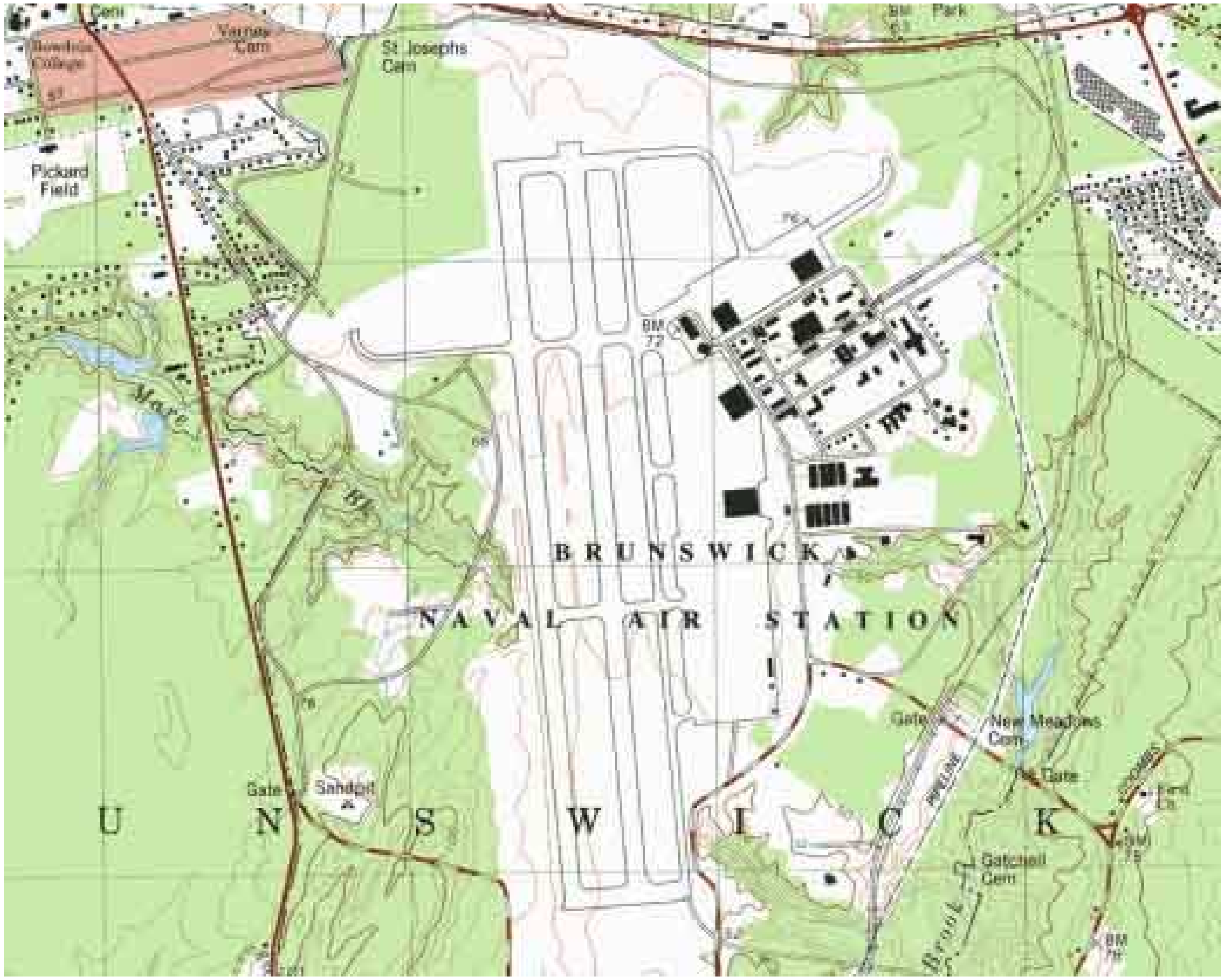


Figure 2. Mere Brook reference location

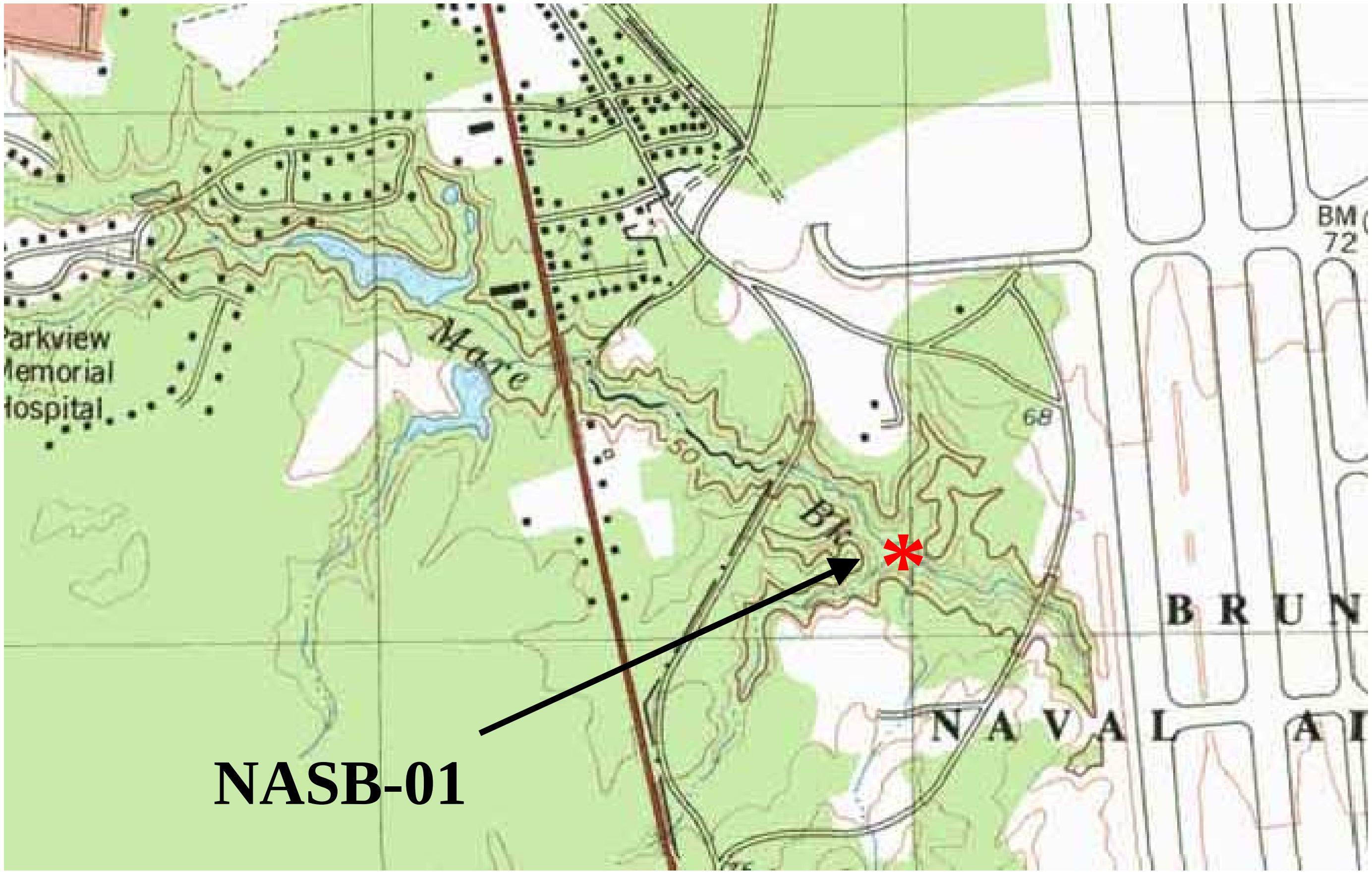
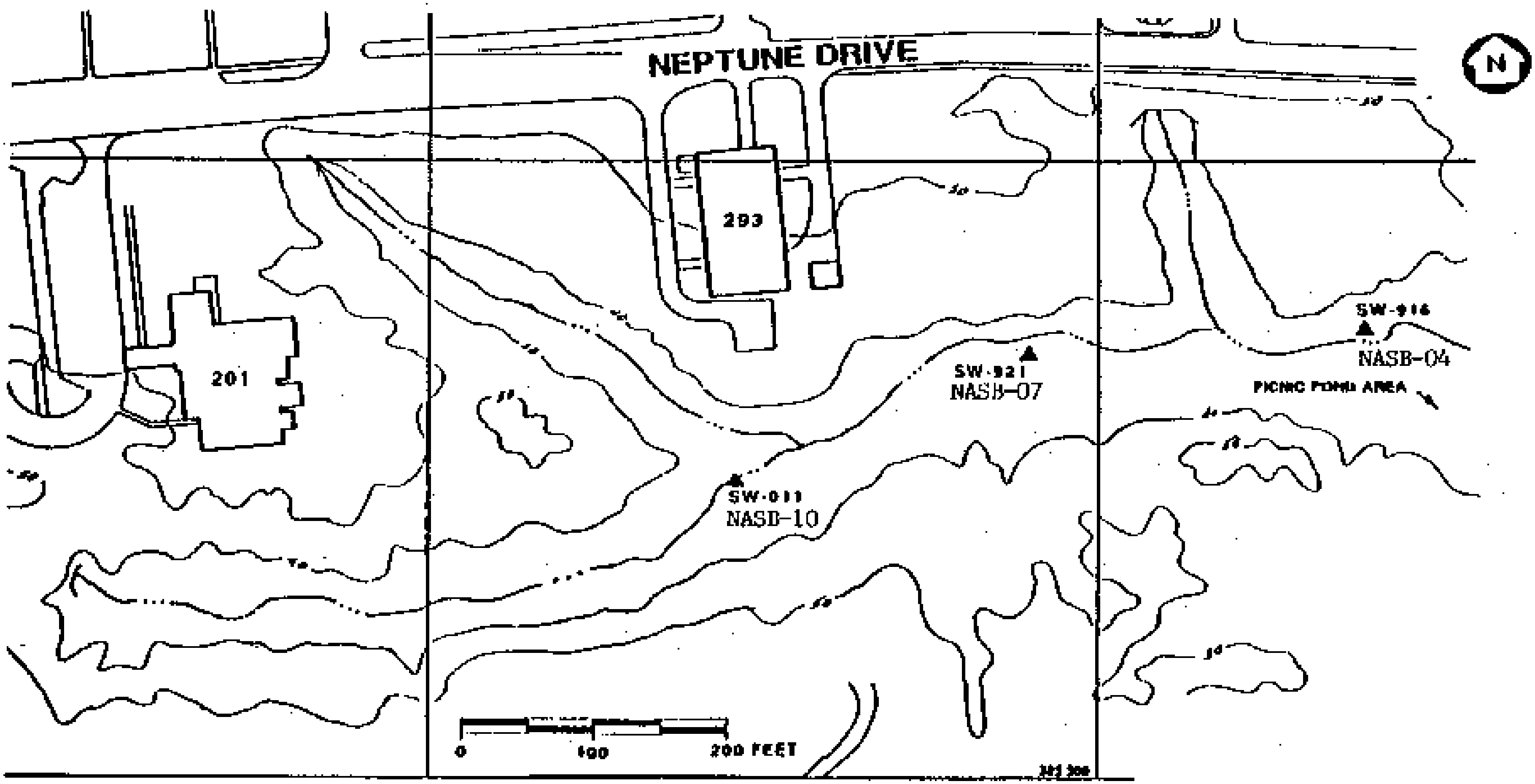
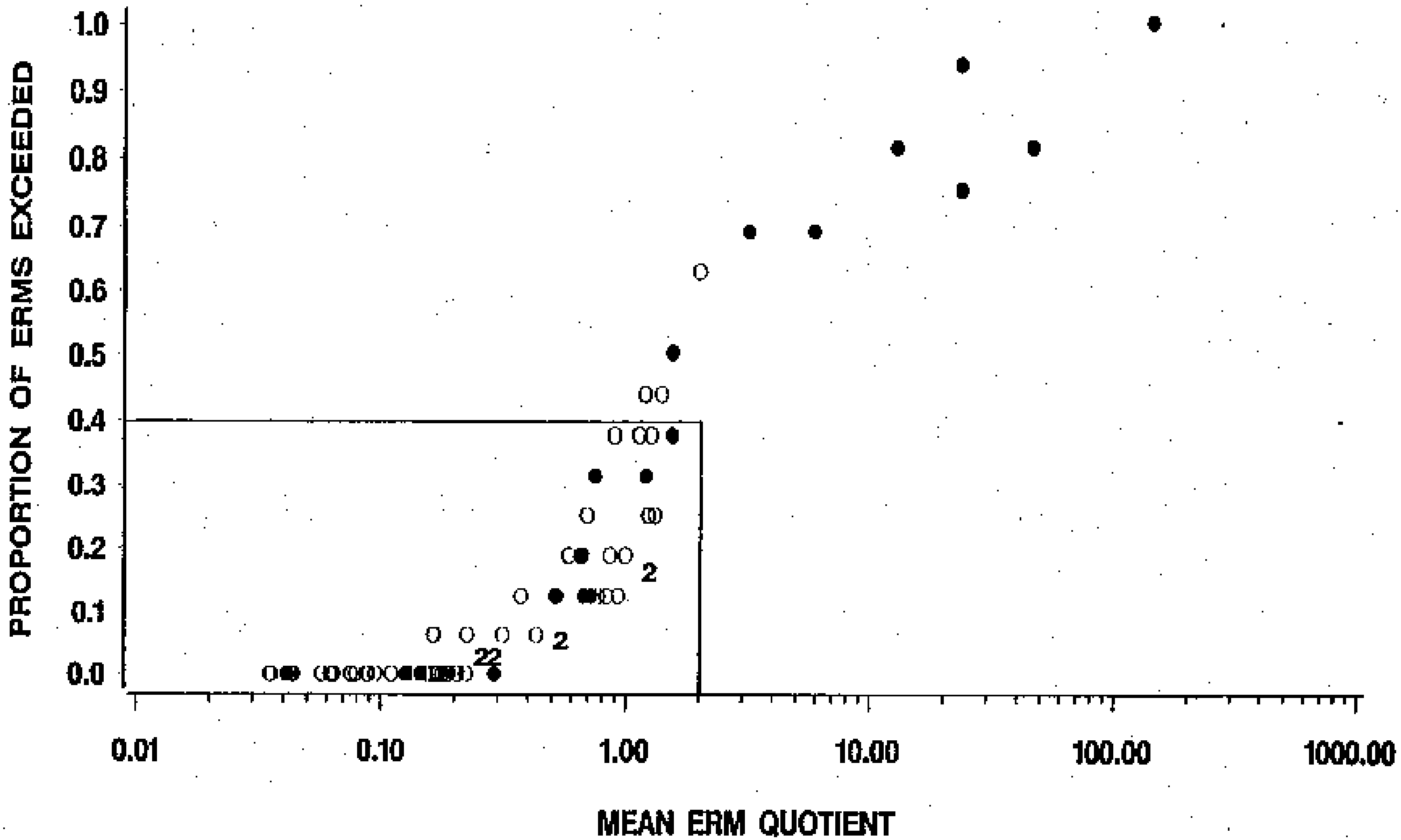


Figure 3. Approximate sediment collection locations in the Site 9 stream.



ADAPTED FROM ABB (1994)

Figure 4. Proportion of ERMs exceeded vs. the mean ERM quotient. The open circles represent non-toxic samples and the solid circle represent toxic samples for *Hyalella azteca* 28-d toxicity tests reported in Ingersoll et al. (1996) or Kemble et al. (1996). Samples in the present study are designated with the number 2.



TABLES

Table 1. Remedial Investigation and USFWS/NBS sampling locations

Sample Location	RI Study	Sample # This Study
Mere Brook (reference)		NASB-01,02,03
Site 9 stream	SD-011	NASB-10,11,12
Site 9 stream	SD-921	NASB-07,08,09
Site 9 stream	SD-916	NASB-04,05,06

Table 2. Conditions for conducting sediment tests with *Hyalella azteca* (HA) and *Chironomus tentans* (CT; modified from USEPA 1994 and ASTM 1995).

Parameter	Conditions
1. Test Type:	Whole-sediment with renewal of overlying water
2. Temperature:	23°C
3. Light quality:	Wide-spectrum fluorescent lights
4. Illuminance:	about 500 to 1000 lux
5. Photoperiod:	16L:8D
6. Test chamber:	300-ml high-form lipless beaker
7. Sediment volume:	100 ml
8. Overlying water:	175 ml in the sediment exposures (275 ml in the water-only exposure from Day 28 to Day 42 of the HA test).15. Source of overlying water was well water (hardness 283 mg/L as $CaCO_3$).
9. Renewal water:	2 volume additions/d
10. Age of organisms:	HA: 7-d old CT: 3rd instar
11. Organisms/beaker:	10
12. Number replicates/ sediment:	HA: 8 (4 for 28-d survival and growth and 4 for 42-d survival and reproduction) CT: 4
13. Feeding:	HA: 1.5 ml YCT (1800 mg/L stock) three times/week. Note: subsequent studies have modified this feeding rate to 1.0 ml of YCT daily. CT: 1.5 ml of a Tetrafin suspension (4 g/L) daily.
14. Aeration:	None, if DO >3.5 mg/L (40% of saturation) in overlying water
15. Beaker cleaning:	Gently brush screens on <u>outside</u> of beakers as needed
16. Water quality:	Hardness, alkalinity, conductivity, pH, ammonia at start and end. Temperature daily. Dissolved oxygen (DO) weekly.
17. Test duration:	HA: 42 d CT: 10 d
18. Endpoints:	HA: (1) 28-d survival, length, and weight; (2) 42-d survival, reproduction; and (3) number of adult males and females on Day 42. CT: 10-d survival, head capsule width, and weight
19. Test acceptability:	Minimum mean control survival of 80% on Day 28 for the amphipod test and 70% on Day 10 of the midge test. Minimum mean control weight of 0.6 mg (dry weight) for surviving organisms in the midge test. Additional performance-based criteria are outlined in USEPA (1994) and ASTM (1995).

Table 3. Mean measured overlying water quality for the whole-sediment tests conducted with sediments collected from U.S. Naval Air Station in Brunswick Maine. Water quality was conducted on Days 0, 7,14, 21, and 27 of the *Hyalella azteca* test and Days 0 and 9 of the *Chironomus tentans* test.

Sample	pH	Alkalinity (mg/L)	Total hardness (mg/L)	DO (mg/L)	Conductivity (:mho @25°C)	Unionized ammonia (mg/L)	Total ammonia (mg/L)
Hyalella azteca test							
NASB-01	8.14	206	220	6.38	520	0.001	0.169
NASB-04	8.30	181	211	7.02	528	0.001	0.058
NASB-07	8.30	181	217	7.00	529	0.001	0.046
NASB-10	8.28	198	214	7.13	528	0.000	0.162
Control	8.17	175	210	6.94	517	0.002	0.287
Mean	8.24	188	214	6.89	524	0.001	0.144
Max.	8.30	206	220	7.13	529	0.002	0.287
Min.	8.14	175	210	6.38	517	0.000	0.046
Std	0.07	12	4	0.27	5	0.000	0.088
Median	8.28	181	214	7.00	528	0.001	0.162
Chironomus tentans test							
NASB-01	8.02	185	206	6.59	526	0.002	0.301
NASB-04	819	162	185	6.95	531	0.002	0.321
NASB-07	8.22	162	193	6.80	529	0.001	0.171
NASB-10	8.19	174	198	7.05	529	0.001	0.153
Control	7.95	177	214	6.47	517	0.002	0.494
Mean	8.11	172	199	6.77	526	0.002	0.288
Max.	8.22	185	214	7.05	531	0.002	0.494
Min.	7.95	162	185	6.47	517	0.001	0.153
Std	0.11	9	10	0.22	5	0.000	0.123
Median	8.19	174	198	6.80	529	0.002	0.301

Table 4. Pore-water quality for the whole-sediment tests conducted with sediments collected from U.S. Naval Air Station in Brunswick Maine. Total sulfide was <0.1 mg/L and hydrogen sulfide was <0.05 mg/L for all samples.

Sample	pH	Alkalinity (mg/L)	Total hardness (mg/L)	DO (mg/L)	Conductivity (µmho/cm)	Unionized ammonia (mg/L)	Total ammonia (mg/L)
NASB-01	7.06	130	108	6.97	327	0.002	2.640
NASB-04	7.10	125	50	8.06	312	0.001	1.880
NASB-07	6.85	52	76	8.14	290	0.000	0.796
NASB-10	7.10	54	66	8.76	243	0.000	0.611
Control	7.35	126	160	7.17	303	0.002	1.800
Mean	7.09	97	92	7.82	295	0.001	1.550
Max.	7.35	130	160	8.76	327	0.002	2.640
Min.	6.85	52	50	6.97	243	0.000	0.611
Std.	0.16	36	39	0.66	29	0.001	0.750
Median	7.10	125	76	8.06	303	0.001	1.800

Table 5. Physical and chemical characteristics of sediments and proportion of ERMs exceeded and mean ERM quotients from samples from the U.S. Naval Air Station in Brunswick Maine. NR = Not reported in Figure 4 for the control sediment.

Sample	LOI[a] (%)	Solids (%)	Particle Size (%)			Sediment classification	Proportion of ERMs exceeded	Mean ERM Quotient
			sand	clay	silt			
NASB-01	4.9	56.4	83.1	13.9	3.0	Loamy sand	0.03	0.29
NASB-04	0.4	82.3	90.5	8.9	0.6	Sand	0.05	0.55
NASB-07	0.4	81.8	90.4	8.9	0.7	Sand	0.16	1.25
NASB-10	0.4	83.3	91.7	8.3	0.0	Sand	0.03	0.26
Control	NR	NR	73.6	16.3	10.1	Sandy loam	NR	NR

[a] LOI = loss on ignition, calculated as [(wgt. at 100°C) - (wgt. at 500°C)] ÷ wgt. at 100°C x 100

Table 6. Results of the 42-d toxicity test conducted with sediments collected from U.S. Naval Air Station in Brunswick Maine with the amphipod *Hyalella azteca*. Means (standard error of the means in parentheses) within a column followed by a common letter are not significantly different ($p > 0.05$; $n=4$ for all samples except for Day 28 survival where $n=8$). Starting body length of amphipods was 1.16 (0.03 SE, $n=20$).

Sample	Survival (%) Day 28	Survival (%) Day 35	Survival (%) Day 42	Length (mm)[1] Day 28	Weight/individual (mg) Day 28	Number of young/female Days 28 to 42
Control	98 (4.5)	100 (0)	100 (0)	3.3 (0.06)b	0.35 (0.07)	1.2 (0.46)
NASB-01	98 (1.1)	98 (2.5)	95 (2.8)	3.4 (0.14)b	0.29 (0.02)	3.3 (0.64)
NASB-04	93 (2.2)	93 (4.8)	93 (7.5)	3.3 (0.07)b	0.29 (0.02)	2.8 (1.12)
NASB-07	97 (1.2)	100 (0)	100 (0)	3.5 (0.09)b	0.25 (0.02)	1.1 (0.31)
NASB-10	94 (1.8)	90 (7.1)	93 (7.5)	4.2 (0.38)a	0.22 (0.01)	0.9 (0.42)

Table 7. Results of 10-d toxicity test conducted with sediments collected from U.S. Naval Air Station in Brunswick Maine with the midge *Chironomus tentans.* Means (standard error of the means in parentheses) within a column followed by a common letter are not significantly different ($p > 0.05$; $n=4$). Mean head capsule width of midges at the start of the test was 0.32 mm (0.03 SE) and mean starting weight was 1.3 mg ($n=13$).

Sample	Survival (%)	Head capsule width (mm)[1]	Weight/individual (mg)
Control	75 (8.7)	0.65 (0.01)bc	2.00 (0.18)
NASB-01	60 (14.7)	0.64 (0.01)bcd	1.89 (0.14)
NASB-04	85 (6.5)	0.62 (0.01)d	1.43 (0.47)
NASB-07	63 (2.5)	0.66 (0.01)ab	1.69 (0.27)
NASB-10	60 (4.1)	0.68 (0.01)a	2.61 (0.18)

Table 8. Concentrations of PAHs in NASB sediment samples. Results expressed as mg/Kg (ppm) dry weight.

PAH	NASB 01 (Reference)	NASB 04	NASB 07	NASB 10	ERL (15th Percentile)	ERM (50th Percentile)
Acenapthylene			0.1			
Fluorene			0.2			
Phenanthrene	0.1	0.4	1.3	0.1		
Anthracene	0.1		0.3			
2-Methylphenanthrene			0.1			
Fluoranthrene	0.3	0.6	1.4	0.3		
Pyrene	0.2	0.6	1.2	0.3		
Benz(a)anthracene		0.3	0.5	0.1		
Chrysene	0.2	0.3	0.6	0.2		
Benzo(b)fluoranthene	0.1	0.2	0.4	0.1		
Benzo(k)fluoranthene	0.1	0.2	0.3	0.1		
Benzo(a)pyrene	0.1	0.2	0.4	0.1		
Perylene			0.1			
Indeno(1,2,3-cd)pyrene		0.1	0.2			
Dibenzo(a,h)anthracene			0.1			
Benzo(g,h,i)perylene		0.2	0.2			
C3-Napthalenes		0.2	0.2			
C1-Phenanthrenes	0.1	0.3	0.4	0.1		
C2-Phenanthrenes	0.1	0.2	0.2			
C3-Phenanthrenes		0.1				
C1-Chrysenes		0.1	0.3			
C1-Fluoranthenes+C1-Pyrenes	0.2	0.2	0.5	0.1		
Total PAHs	1.6	4.2	9	1.5	0.240	2.200

Table 9. Concentrations of metals in NASB sediment samples. Results expressed as mg/Kg (ppm) dry weight.

Sample No.	Al	Be	Cd	Cr	Cu	Fe	Pb	Mg	Mn	Mo	Ni	V	Zn
NASB-01 (Reference)	1,880	0.3	BDL	4.31	4.25	3,290	14.3	416	283	BDL	3.74	5.22	33.9
NASB-04	866	BDL	BDL	3.13	5.05	1,650	12.3	150	96.3	BDL	1.61	3.20	22.8
NASB-07	945	BDL	0.25	12.8	4.93	1,690	34.8	205	103	BDL	1.69	3.50	23.6
NASB-10	715	BDL	BDL	1.94	3.81	897	6.01	118	64.3	0.238	1.06	2.17	13.3
Mean (04,07,10)	842	nc	nc	5.96	4.60	1,412	17.7	157.7	87.9	nc	1.45	2.96	19.9
ERL (15th Percentile)	14,000	na	0.70	39	41	20%	55	na	730	na	24	na	110
ERM (50th Percentile)	58,000	na	3.9	270	190	28%	99	na	1,700	na	45	na	550

BDL = below detection limit
nc = not calculated
na = not available
As, B, Hg, Se, and Sr were below detection limits at all locations.

Table 10. Summary of sediment characteristics - AVS/SEM. AVS and 3SEM expressed as :Mol/g.

Location	AVS	3SEM	SEM/AVS
Mere Brook - Reference			
NASB-01	2.16	0.077	0.356
NASB-02	3.37	0.674	0.200
			SEM-AVS
Site 9 Stream			
NASB-04	0.023	0.517	0.494
NASB-05	0.006	0.542	0.536
NASB-07	0.005	0.465	0.460
NASB-08	0.002	0.582	0.580
NASB-10	0.003	0.573	0.570
NASB-11	0.003	0.411	0.408

APPENDIX A

AVS/SEM Determinations - Report FY96-32-07
US Department of the Interior
National Biological Survey
Midwest Science Center
Columbia, MO

Available by request from:

US Fish and Wildlife Service
1033 South Main Street
Old Town, ME 04468

APPENDIX B

PCBs, Organochlorines, PAHs and Total Recoverable Metals in Sediments - Report FY96-32-09 (Revised 1/24/97)

US Department of the Interior
National Biological Survey
Midwest Science Center
Columbia, MO

Available by request from:

US Fish and Wildlife Service
1033 South Main Street
Old Town, ME 04468